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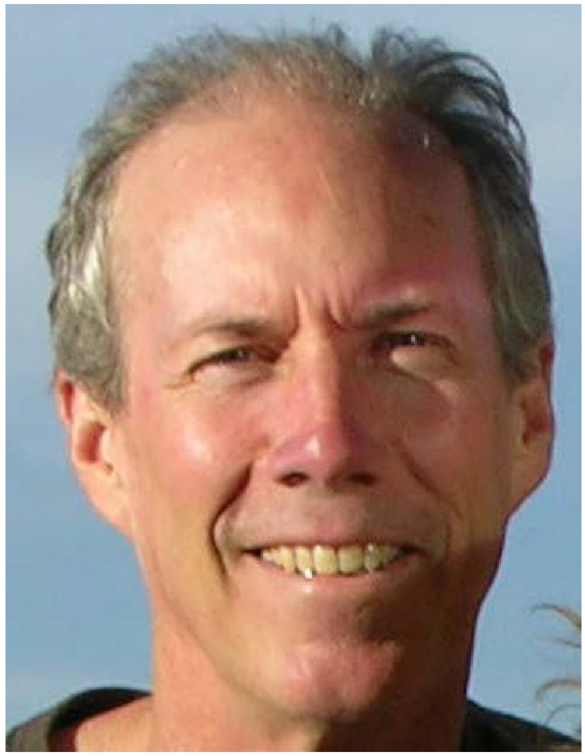
"What Do Resistivity Reversals Tell Us about the Dj Basin Niobrara Petroleum System?"

Abstract

Resistivity mapping has been the primary tool for Niobrara exploration in the DJ Basin since the landmark paper of Smagala et al. (1984). Niobrara productivity is generally poor in areas of less than 30 ohm-m and improves as resistivity increases. This increase in resistivity corresponds to an increase in thermal maturity as documented by Smagala et al. (1984). However, resistivity decreases in the most productive and thermally mature area of the basin within Wattenberg field. A leasing program based on Niobrara resistivity mapping would have missed the best area in the basin. Al Duhailan and Cumella (2014) documented resistivity reversals in the Niobrara in the DJ, Piceance, and Sand Wash basins. The cause of the reversals are poorly understood and some possible mechanisms are discussed in the paper. Of the possible mechanisms that are mentioned, changes in wettability may be the most viable. Jack Breig (personal communication) has suggested that changes in wettability may be responsible for the decrease in resistivity with increased maturation. In immature settings, the resistivity is relatively low, dominated by the conductive properties of a continuous phase of pore-filling water. In the oil generation window, source rocks generate both non-polar hydrocarbon liquids (saturates and aromatics) and polar organic compounds (e.g., resins, asphaltenes). The non-polar hydrocarbons displace water from the center of the pore spaces, leading to an increase in electrical resistivity (Archie-equation type phenomenon). Meanwhile, the generated polar organic compounds begin to compete with water to coat carbonate and siliciclastic grain surfaces, slowly but effectively changing the wettability of the rock. At some critical stage or saturation, this leads to a profound disruption of the conductive, continuous water phase and a significant jump in electrical resistivity ensues. In the advanced stages of maturation, thermal cracking affects both kerogen and previously generated oil. As the resins and asphaltenes become cannibalized, their oil-wetting behavior is reversed, releasing grain surfaces to be rewetted by connate water. The conductive water phase, even at low water saturations, is restored and resistivity drops. The area of Wattenberg where the resistivity reversal occurs has measured vitrinite maturities of over 1.4, within the maturity range where most of the liquid hydrocarbons have been cracked to gas. This area also has the highest GORs in the basin, also consistent with a transition to dry gas and a reversion back to water wetness.

Our Presenter

Steve Cumella



Steve Cumella is a consulting geologist in Denver, Colorado, working primarily for Whiting since 2014. He received his bachelors and masters in geology at University of Texas at Austin and started his career with Chevron in 1981. Steve worked the Piceance Basin and other Rocky Mountain basins at Barrett Resources, Williams, Bill Barrett Corporation, and Endeavour International. He was awarded Rocky Mountain Association of Geologists' Outstanding Scientist Award in 2005 and AAPG's Robert H. Dott, Sr. Memorial Award for Best Special Publication in 2010. He was an AAPG Distinguished Lecturer in 2011. He is past executive editor of the Mountain Geologist and was president of the Grand Junction Geological Society in 1991. Steve has authored several publications, given numerous presentations, and led several fieldtrips.